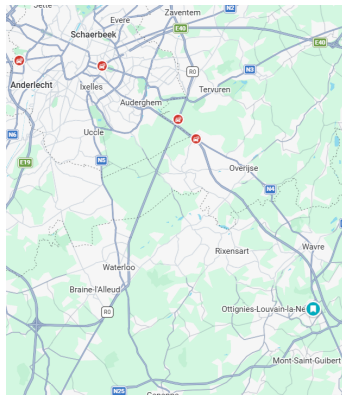


Les mathématiques appliquées ?

Prof. Geovani Nunes Grapiglia

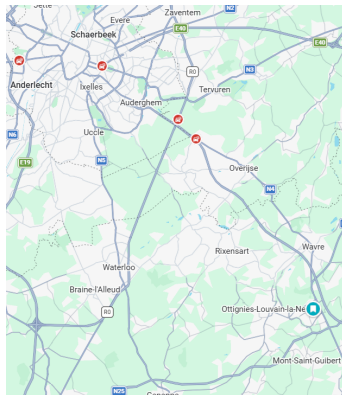
Presentation MAP
September 2026

Shortest Path Problem



Problem: To go from Louvain-la-Neuve train station to Grand Place in Brussels by car, **which route should I take?**

Shortest Path Problem

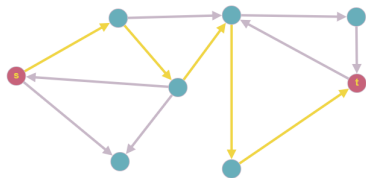


Problem: To go from Louvain-la-Neuve train station to Grand Place in Brussels by car, **which route should I take?**

Goal: Find the path with the **minimum travel time**.

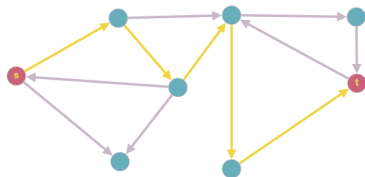
Shortest Path Problem

Graph Model:



Shortest Path Problem

Graph Model:



Optimization Problem:

$$\begin{aligned} \min_{x \in \mathbb{R}^n} \quad & f(x) := \sum_{j=1}^n c_j x_j, \\ \text{s.t.} \quad & Mx = b, \\ & x \in \{0, 1\}^n \end{aligned}$$

Shortest Path Problem

Simplex Algorithm:

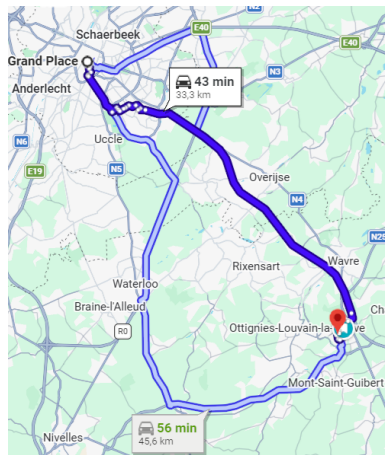
1. $x_B = B^{-1}b, \quad x_N = 0$
2. $\pi^\top = c_B^\top B^{-1}, \quad \bar{c}_N = c_N - M_N^\top \pi$
3. $\bar{c}_N \geq 0 \Rightarrow \text{STOP}$
4. $\bar{c}_j < 0 \Rightarrow j \text{ enters}$
5. $d_B = -B^{-1}M_j, \quad d_j = 1$
6. $\theta^* = \min_{d_{B_i} < 0} \frac{x_{B_i}}{-d_{B_i}}$
7. $x \leftarrow x + \theta^* d, \quad B \leftarrow B'$
8. Repeat.

Shortest Path Problem

Simplex Algorithm:

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8. Repeat.

Solution:



Applied Mathematics

Real-World Problem

Applied Mathematics

Real-World Problem



Mathematical Model

(Graph, Differential Equation, Neural Network, . . .)

Real-World Problem



Mathematical Model

(Graph, Differential Equation, Neural Network, ...)



Mathematical Problem

(Linear System, Optimization, Eigenvalue Problem, ...)

Real-World Problem



Mathematical Model

(Graph, Differential Equation, Neural Network, ...)



Mathematical Problem

(Linear System, Optimization, Eigenvalue Problem, ...)



Algorithm

(Cholesky, Gradient Descent, Power Method, ...)

Real-World Problem



Mathematical Model

(Graph, Differential Equation, Neural Network, ...)



Mathematical Problem

(Linear System, Optimization, Eigenvalue Problem, ...)



Algorithm

(Cholesky, Gradient Descent, Power Method, ...)



Solution

Filière en Mathématiques Appliquées

1. LINMA1315: Compléments d'analyse
2. LINMA1702: Modèles et méthodes d'optimisation I
3. LINMA1170: Algèbre linéaire numérique
4. LINMA1691: Mathématiques discrètes I : Théorie des graphes
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MAP courses focus on rigorous analysis and understanding:

3.2.1 Value iteration

Given an initial approximation V^0 for V^* appearing in (3.5), a sequence of approximations is defined recursively via

$$V^{n+1}(x) = \min_u \{c(x, u) + V^n(F(x, u))\}, \quad x \in \mathbf{X}, \quad n \geq 0 \quad (3.8)$$

Recursions like this to solve fixed point equations are generally known as *successive approximation*. In Exercise 3.5 you will establish the following interpretation:

$$V^{n+1}(x) = \min_{u_{[0,n]}} \left\{ \sum_{k=0}^n c(x(k), u(k)) + V^0(x(n+1)) \right\}, \quad x(0) = x \in \mathbf{X}. \quad (3.9)$$

The VIA is convergent under very general conditions: for each x

$$\lim_{n \rightarrow \infty} [V^n(x) - V^n(x^e)] = J^*(x)$$

Here is the simplest result of this kind:

Proposition 3.2. *Consider the VIA under the following assumptions:*

- (i) *The state space $\mathbf{X}$ and input space $\mathbf{U}$ are finite.*
- (ii) *The cost function c is non-negative, vanishes only at (x^e, u^e) , and J^* is finite valued.*
- (iii) *The initialization V^0 is chosen with non-negative entries, and $V^0(x^e) = 0$.*

Then, there is $n_0 \geq 1$ such that

$$V^n(x) = J^*(x), \quad x \in \mathbf{X}, \quad n \geq n_0$$

Proof. Let ϕ^* be an optimal policy, and let $n_0 \geq 1$ denote a value such that $(x^*(k), u^*(k)) = (x^e, u^e)$ for $k \geq n_0$. Such an integer exists because J^* is finite valued.

We have from (3.9)

Options du Master MAP

Disciplines fondamentales (20 crédits)	1. Optimization and operations research engineering 2. Systems and control engineering 3. Computational data engineering and machine learning
Domaines d'application	4. Artificial Intelligence and its applications 5. Financial mathematics 6. Cryptography & information security (ELEC/INFO) 7. Biomedical engineering
Economie et gestion	8. Business risks and opportunities 9. Launching of small and medium-sized companies (CPME)

Métiers et débouchés

Quelques entreprises ayant récemment engagé nos diplômés

- **Énergie**

Electrabel, GDF-Suez, Tractebel Engineering

- **Finances & assurances**

BNP Paribas Fortis, Aon Global Risk Consulting, ING, Mercer, Secura-re, Reacfin, régulateurs

- **Consultance**

Deloitte Consulting, PriceWaterhouseCoopers, McKinsey, Bain & Company

- **Industrie aéronautique et spatiale :** CENAERO

- **Startups:** Cowboy, Riaktr

- **Industrie de production**

Procter & Gamble, Solvay S.A., GSK

- **Industrie pharmaceutique**

Baxter, Merck

- **Informatique**

Altran, Sopra, Amadeus, Axen, Mainsys, SIM Corp., Google

- **Transports** Strattec

- **Consultance technologique**

N-Side, ARHS Developments, OM Partners, Capgemini, Eura Nova, HERMES Engineering

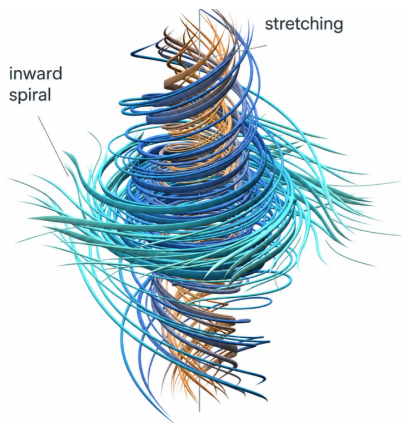
Thibault Sottiaux: From MAP to product lead at OpenAI



https://www.youtube.com/watch?v=0X0ypK7_90c&t=1s

Navier-Stokes Millennium Prize Problem

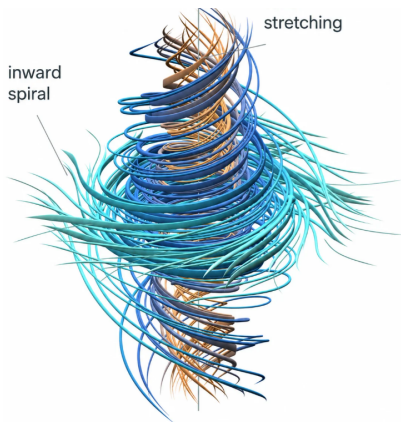
Possible Solution obtained by GPT-6 Astra (AI Mathematical Model)



Applied Mathematics Tools Are Tackling Open Problems in Pure Mathematics...

Navier-Stokes Millennium Prize Problem

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Applied Mathematics Tools Are Tackling Open Problems in Pure Mathematics...

Very exciting times for Applied Mathematics!

Pour plus d'informations

- N'hésitez pas à nous contacter
- De nombreuses informations sont disponibles à partir du site intranet de la commission de programme MAP:

<https://intranet.uclouvain.be/fr/myucl/facultes/epl/map>

+ Moodle MAP

